Radial	Perkins-Kern-Nordgren	Geertsma-deKlerk
$(S_f)_{RAD} = \frac{3\pi E'}{16 r_f}$	$(S_f)_{PKN} = \frac{2E'}{\pi h_f}$	$(S_f)_{GDK} = \frac{E'}{\pi L_f}$

Table 1—Fracture stiffness for 2D fracture models.

FIGURE 1

211 212 213 214

	Defined terms	Basic linear Equation using Pressure and Time as variables:	Basic linear Equation using Adjusted Pseudopressure and Time as variables:	Basic linear Equation using Adjusted Pseudopressure and Adjusted Pseudotime as variables:
201		$y_n = b_M + m_M x_n$	$(y_a)_n = b_M + m_M (x_a)_n$	$(y_{ap})_n = b_M + m_M (x_{ap})_n$
202	$y_n, (y_a)_n, \text{or } (y_{ap})_n$	$y_n \equiv \dfrac{p_n - p_r}{d_n \sqrt{t_n}\sqrt{t_{ne}}}$	$(y_a)_n \equiv \dfrac{(p_a)_n - p_{ar}}{(d_a)_n \sqrt{t_n}\sqrt{t_{ne}}}$	$(y_{ap})_n \equiv \dfrac{(p_a)_n - p_{ar}}{(d_{ap})_n \sqrt{t_n}\sqrt{t_{ne}}}$
203	$x_n, (x_a)_n, \text{or } (x_{ap})_n$	$x_n \equiv \left[c_1 \left[\dfrac{d_{ne+2}}{d_n}\left(\dfrac{t_n - t_{ne+1}}{t_n t_{ne}}\right)^{1/2} + \sum_{j=ne+3}^{n} \dfrac{[d_j - d_{j-1}]}{d_n}\left(\dfrac{t_n - t_{j-1}}{t_n t_{ne}}\right)^{1/2} \right] + \dfrac{c_2}{d_n t_{ne}^{3/2}}\left[1 - \left(1 - \dfrac{t_{ne+1}}{t_n}\right)^{1/2}\right] \right]$	$(x_a)_n \equiv \left[c_{a1} \left[\dfrac{(d_a)_{ne+2}}{(d_a)_n}\left(\dfrac{t_n - t_{ne+1}}{t_n t_{ne}}\right)^{1/2} + \sum_{j=ne+3}^{n} \dfrac{[(d_a)_j - (d_a)_{j-1}]}{(d_a)_n}\left(\dfrac{t_n - t_{j-1}}{t_n t_{ne}}\right)^{1/2} \right] + \dfrac{c_{a2}}{(d_a)_n t_{ne}^{3/2}}\left[1 - \left(1 - \dfrac{t_{ne+1}}{t_n}\right)^{1/2}\right] \right]$	$(x_{ap})_n \equiv \left[c_{ap1} \left[\dfrac{(d_{ap})_{ne+2}}{(d_{ap})_n}\left[\dfrac{(t_a)_n - (t_a)_{ne+1}}{t_n t_{ne}}\right]^{1/2} + \sum_{j=ne+3}^{n} \dfrac{[(d_{ap})_j - (d_{ap})_{j-1}]}{(d_{ap})_n}\left(\dfrac{(t_a)_n - (t_a)_{j-1}}{t_n t_{ne}}\right)^{1/2} \right] + \dfrac{c_{ap2}(t_a)_n^{1/2}}{(d_{ap})_n t_n^{1/2} t_{ne}^{3/2}}\left[1 - \left(1 - \dfrac{(t_a)_{ne+1}}{(t_a)_n}\right)^{1/2}\right] \right]$

Table 2A—Equations for before-closure pressure-transient fracture-injection/falloff analysis.

200

FIGURE 2

	212	213	214
	Defined terms	Basic equation with Pressure and Time variables	Basic equation with Adjusted Pseudopressure and Time variables	Adjusted Pseudopressure and Adjusted Pseudotime variables
204	$d_j, (d_a)_j$, or $(d_{ap})_j$	$d_j \equiv \dfrac{p_{j-1} - p_j}{t_j - t_{j-1}}$	$(d_a)_j \equiv \dfrac{(\mu_g)_j}{\bar{\mu}_g}\left[\dfrac{[p_a(p)]_{j-1} - [p_a(p)]_j}{t_j - t_{j-1}}\right]$	$(d_{ap})_j \equiv \dfrac{\bar{c}_t}{(c_t)_j}\left[\dfrac{[p_a(p)]_{j-1} - [p_a(p)]_j}{(t_a)_j - (t_a)_{j-1}}\right]$
205	c_1 or c_{a1} or c_{ap1}	$c_1 \equiv \sqrt{\dfrac{\mu}{\phi c_t}}$	$c_{a1} \equiv \sqrt{\dfrac{\bar{\mu}_g}{\phi \bar{c}_t}}$	$c_{a1} \equiv \sqrt{\dfrac{\bar{\mu}_g}{\phi \bar{c}_t}}$
206	c_2 or c_{a2} or c_{ap2}	$c_2 \equiv \dfrac{5.615}{24} S_f w_L \sqrt{\dfrac{\mu}{\phi c_t}}$	$c_{a2} \equiv \dfrac{5.615}{24} S_f w_L \dfrac{\bar{B}_g}{(B_g)_{ne}} \sqrt{\dfrac{\bar{\mu}_g}{\phi \bar{c}_t}}$	$c_{a2} \equiv \dfrac{5.615}{24} S_f w_L \dfrac{\bar{B}_g}{(B_g)_{ne}} \sqrt{\dfrac{\bar{\mu}_g}{\phi \bar{c}_t}}$
207	b_M	$b_M \equiv \dfrac{141.2\pi(24)}{5.615} \dfrac{R_0}{r_p S_f} \dfrac{1}{t_{ne}}$	$b_M \equiv \dfrac{141.2\pi(24)}{5.615} \dfrac{R_0}{r_p S_f} \dfrac{1}{t_{ne}}$	$b_M \equiv \dfrac{141.2\pi(24)}{5.615} \dfrac{R_0}{r_p S_f} \dfrac{1}{t_{ne}}$
208	m_M or $m_{aM}=m_M$ $m_{\omega M}$ for dual porosity	$m_M \equiv \dfrac{(141.2)(2)(0.02878)(24)}{5.615} \dfrac{1}{r_p S_f \sqrt{k}}$ $m_{\omega M} \equiv \dfrac{(141.2)(2)(0.02878)(24)}{5.615} \dfrac{1}{r_p S_f \sqrt{\omega k}}$	$m_M \equiv \dfrac{(141.2)(2)(0.02878)(24)}{5.615} \dfrac{1}{r_p S_f \sqrt{k}}$ $m_{\omega M} \equiv \dfrac{(141.2)(2)(0.02878)(24)}{5.615} \dfrac{1}{r_p S_f \sqrt{\omega k}}$	$m_M \equiv \dfrac{(141.2)(2)(0.02878)(24)}{5.615} \dfrac{1}{r_p S_f \sqrt{k}}$ $m_{\omega M} \equiv \dfrac{(141.2)(2)(0.02878)(24)}{5.615} \dfrac{1}{r_p S_f \sqrt{\omega k}}$

Table 2B (cont'd)—Equations for before-closure pressure-transient fracture-injection/falloff analysis.

200

FIGURE 3

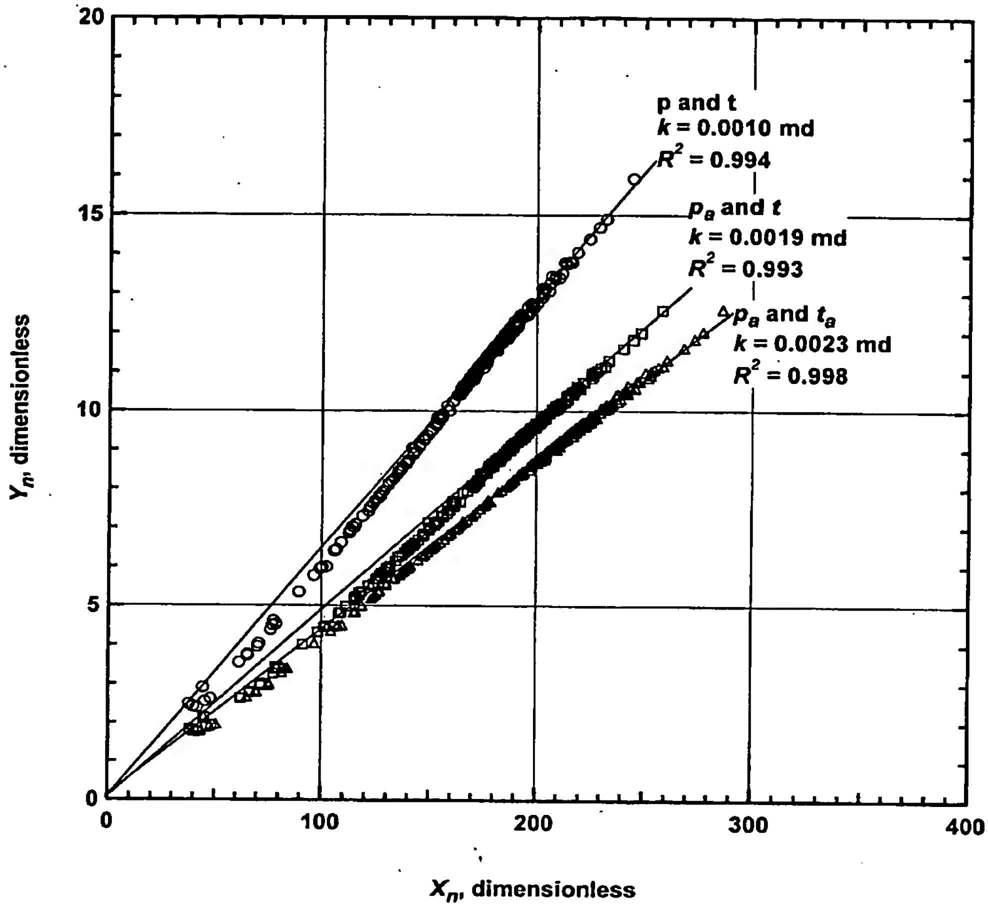
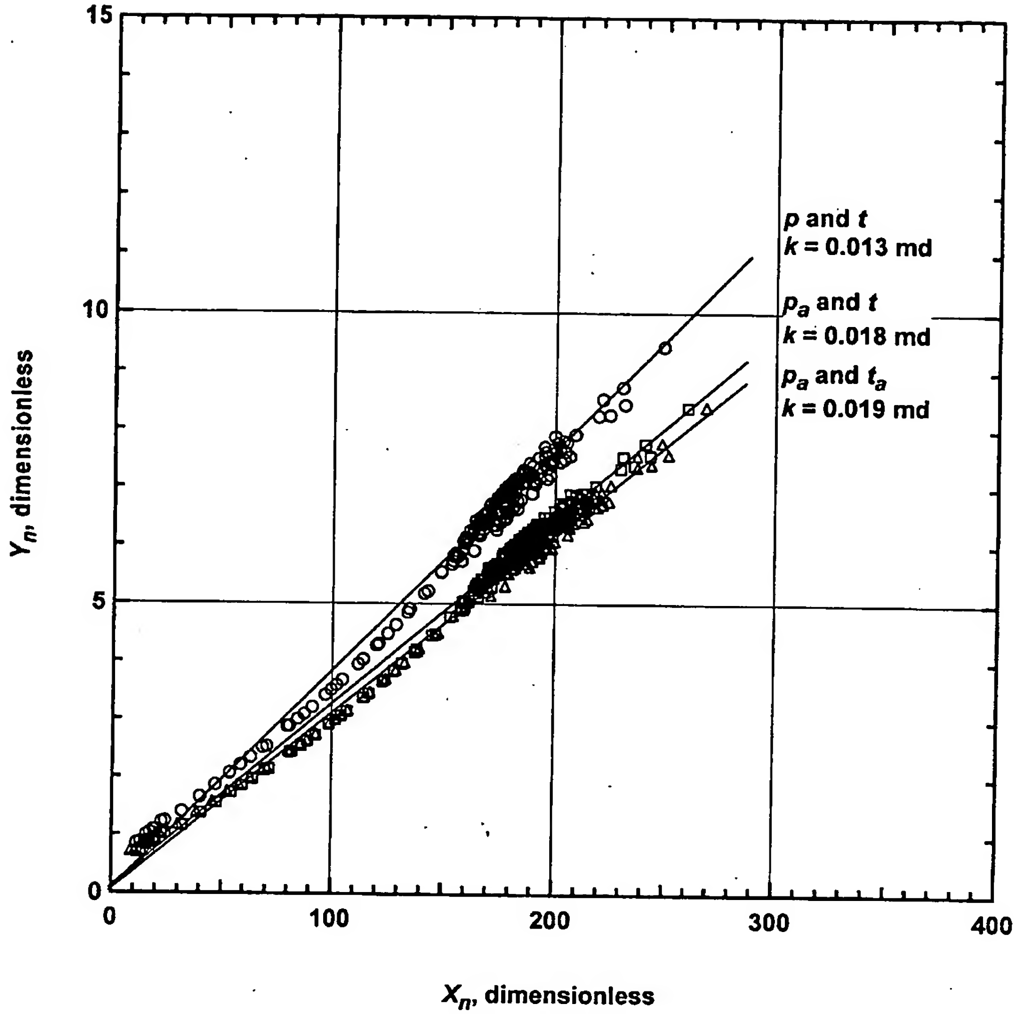
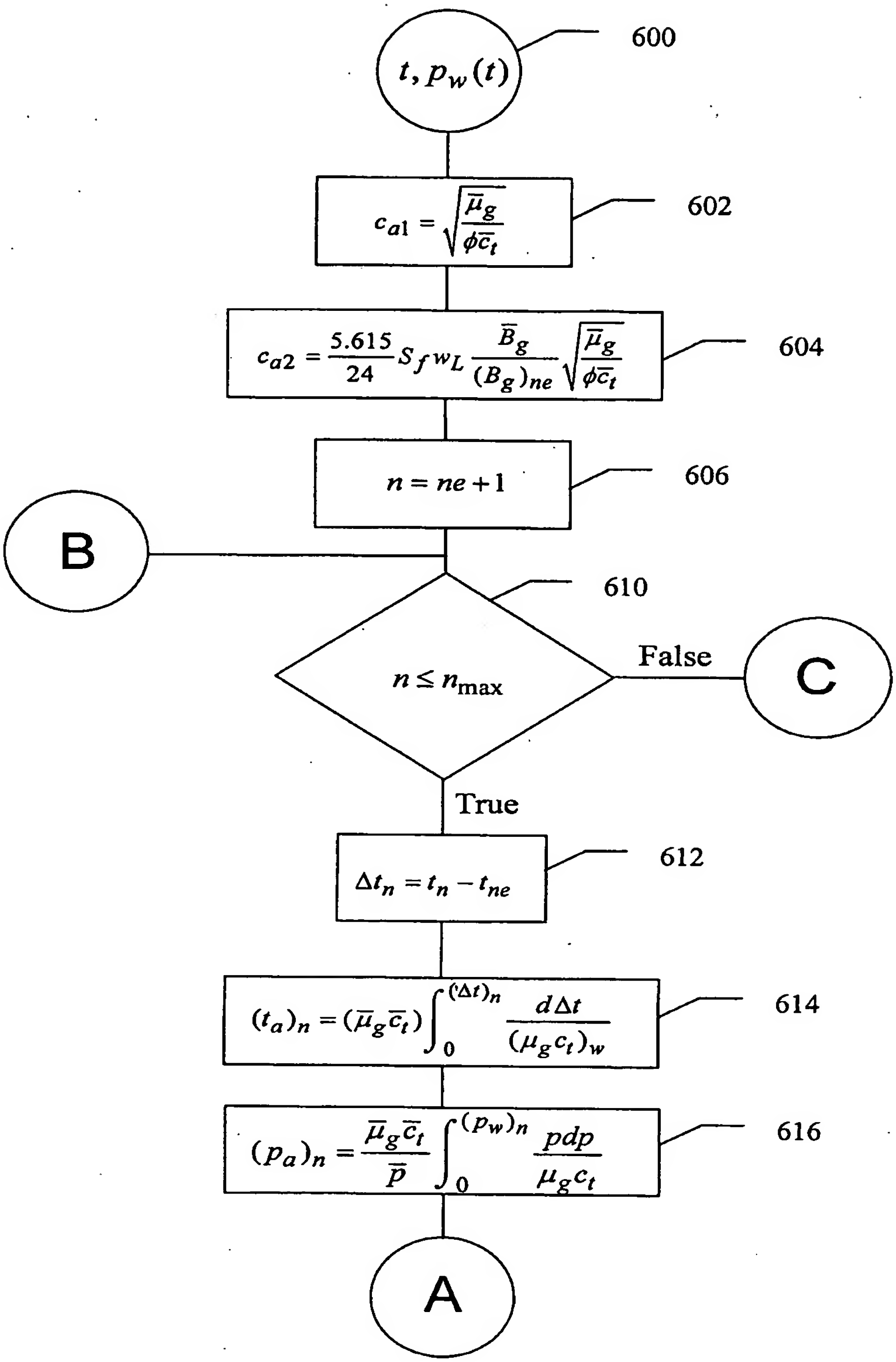

p and t
k = 0.0010 md
R^2 = 0.994
p_a and t
k = 0.0019 md
R^2 = 0.993
p_a and t_a
k = 0.0023 md
R^2 = 0.998
20
15
10
5
0
0
100
200
300
400
Y_n, dimensionless
X_n, dimensionless

FIGURE 4



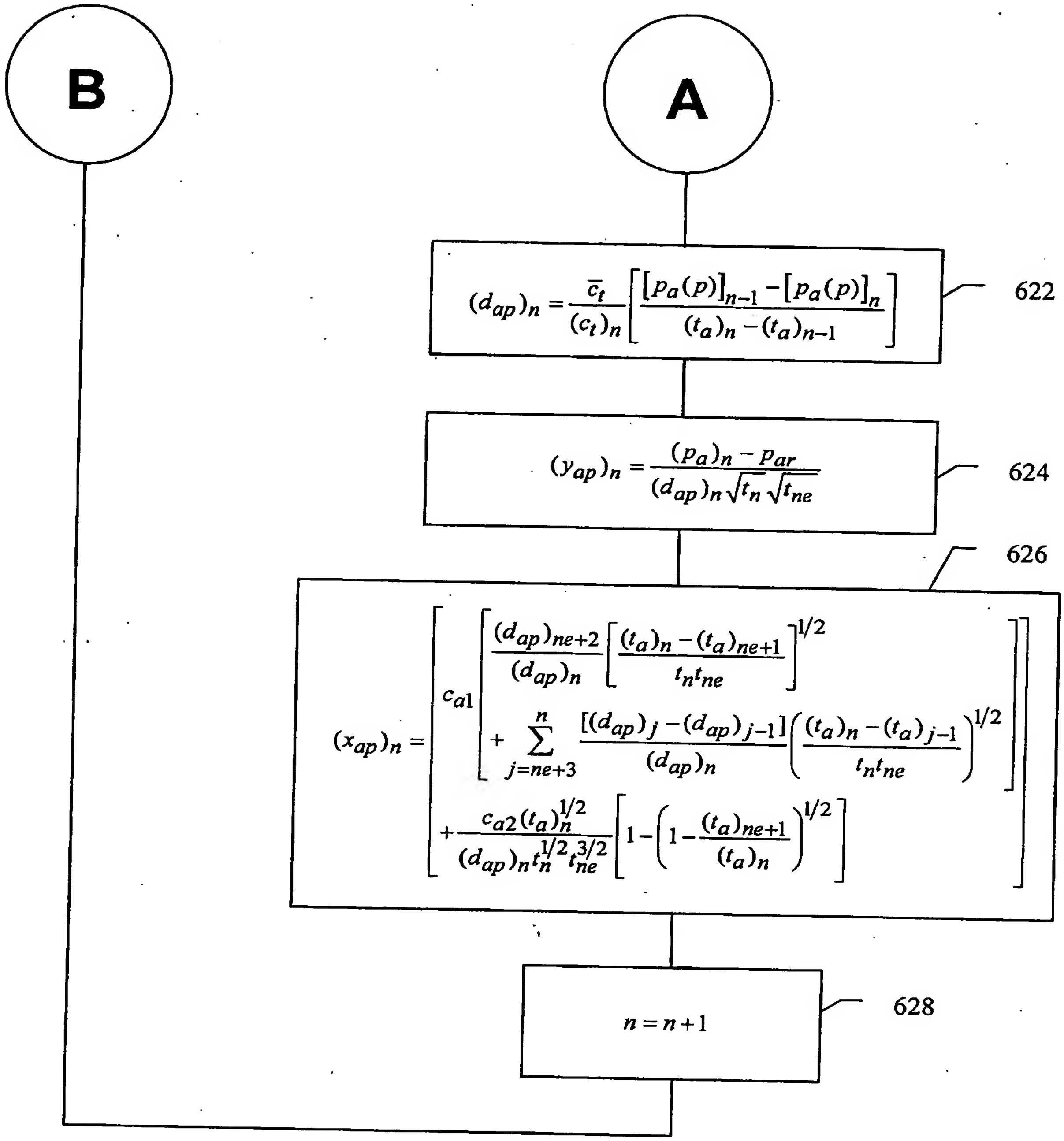
15
10
5
0
0
100
200
300
400
Y_n, dimensionless
X_n, dimensionless
p and t
k = 0.013 md
p_a and t
k = 0.018 md
p_a and t_a
k = 0.019 md

FIGURE 5



$t, p_w(t)$
600
$c_{a1} = \sqrt{\frac{\bar{\mu}_g}{\phi \bar{c}_t}}$
602
$c_{a2} = \frac{5.615}{24} s_f w_L \frac{\bar{B}_g}{(B_g)_{ne}} \sqrt{\frac{\bar{\mu}_g}{\phi \bar{c}_t}}$
604
$n = ne + 1$
606
B
610
$n \leq n_{\max}$
False
C
True
$\Delta t_n = t_n - t_{ne}$
612
$(t_a)_n = (\bar{\mu}_g \bar{c}_t) \int_0^{(\Delta t)_n} \frac{d\Delta t}{(\mu_g c_t)_w}$
614
$(p_a)_n = \frac{\bar{\mu}_g \bar{c}_t}{\bar{p}} \int_0^{(p_w)_n} \frac{p dp}{\mu_g c_t}$
616
A

FIGURE 6A



B
A
$$(d_{ap})_n = \frac{\bar{c}_t}{(c_t)_n}\left[\frac{[p_a(p)]_{n-1} - [p_a(p)]_n}{(t_a)_n - (t_a)_{n-1}}\right]$$
622
$$(y_{ap})_n = \frac{(p_a)_n - p_{ar}}{(d_{ap})_n\sqrt{t_n}\sqrt{t_{ne}}}$$
624
626
$$(x_{ap})_n = \left[c_{a1}\left[\frac{(d_{ap})_{ne+2}}{(d_{ap})_n}\left[\frac{(t_a)_n - (t_a)_{ne+1}}{t_n t_{ne}}\right]^{1/2} + \sum_{j=ne+3}^{n}\frac{[(d_{ap})_j - (d_{ap})_{j-1}]}{(d_{ap})_n}\left(\frac{(t_a)_n - (t_a)_{j-1}}{t_n t_{ne}}\right)^{1/2}\right] + \frac{c_{a2}(t_a)_n^{1/2}}{(d_{ap})_n t_n^{1/2} t_{ne}^{3/2}}\left[1 - \left(1 - \frac{(t_a)_{ne+1}}{(t_a)_n}\right)^{1/2}\right]\right]$$
$n = n + 1$
628

FIGURE 6B

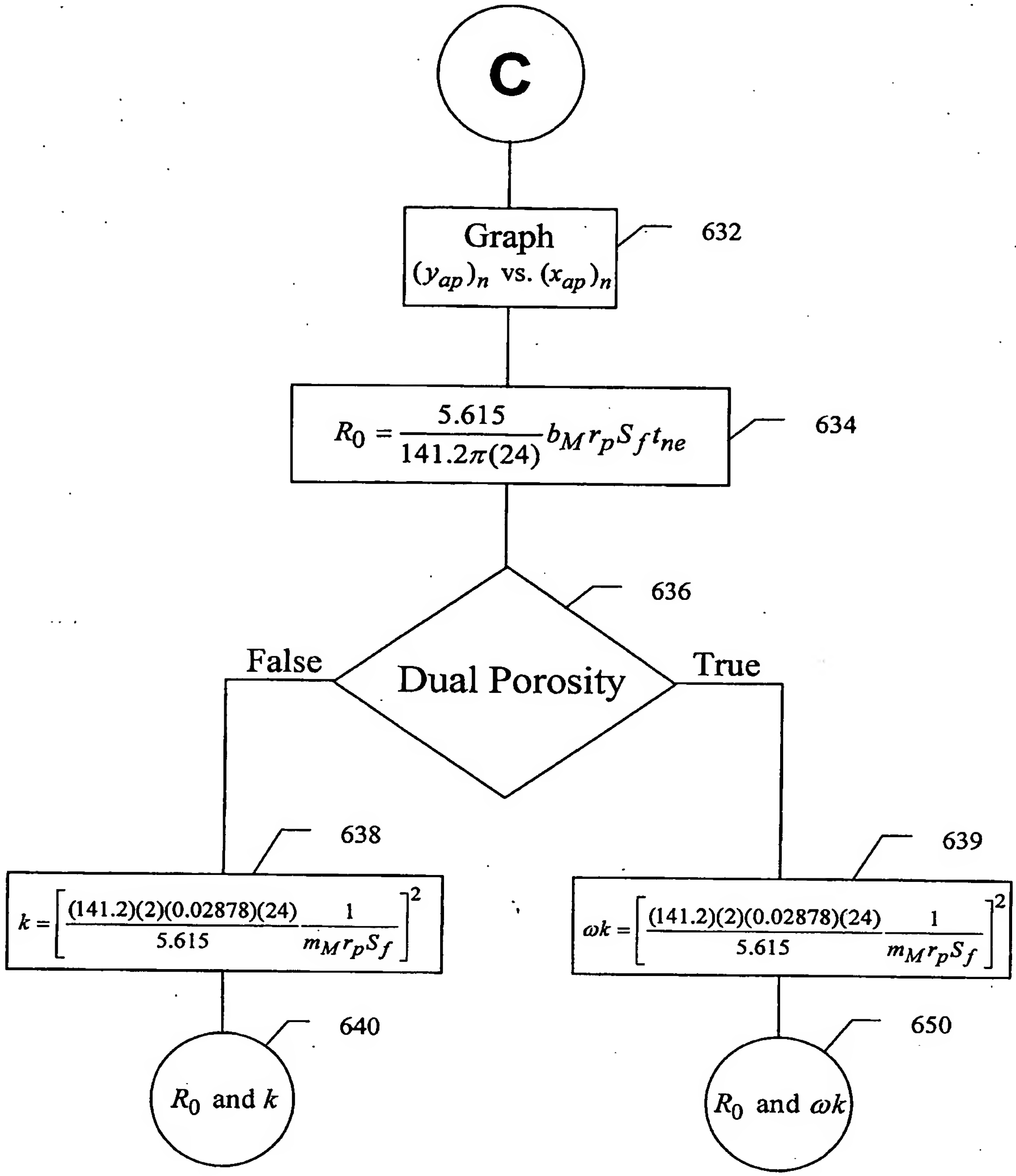
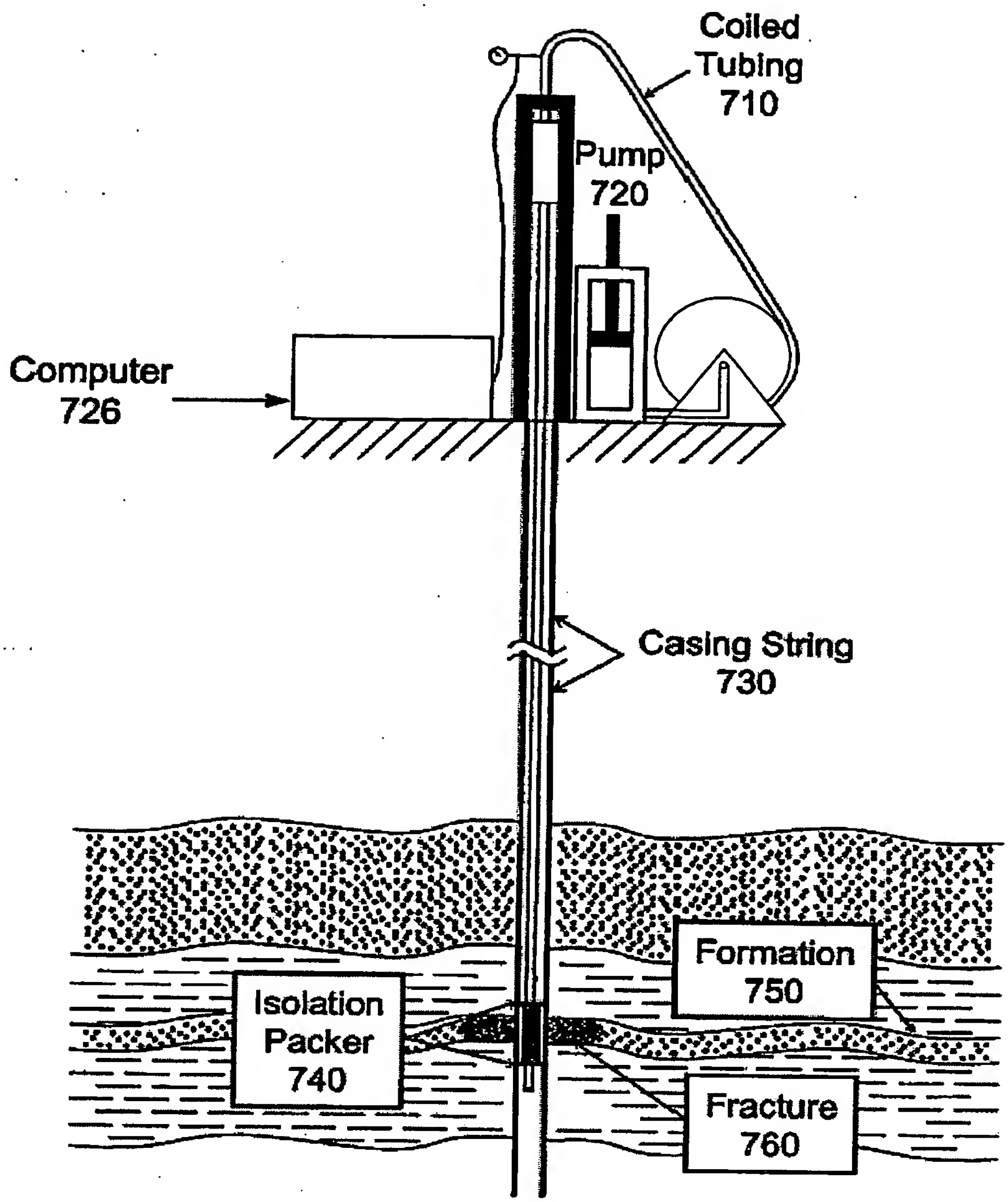

C
Graph
$(y_{ap})_n$ vs. $(x_{ap})_n$
632
$R_0 = \frac{5.615}{141.2\pi(24)} b_M r_p S_f t_{ne}$
634
Dual Porosity
636
False
True
638
$k = \left[\frac{(141.2)(2)(0.02878)(24)}{5.615} \frac{1}{m_M r_p S_f}\right]^2$
639
$\omega k = \left[\frac{(141.2)(2)(0.02878)(24)}{5.615} \frac{1}{m_M r_p S_f}\right]^2$
640
R_0 and k
650
R_0 and ωk

FIGURE 6C



Coiled
Tubing
710
Pump
720
Computer
726
Casing String
730
Formation
750
Isolation
Packer
740
Fracture
760

FIGURE 7